"Caving humbles the soul. Underground I find myself doing things that are unimaginable topside," says Mark S. Cosslett, adventurer and photographer.

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Reaching Uncharted Caves with the Aid of Accurate Carbon Dioxide Measurement

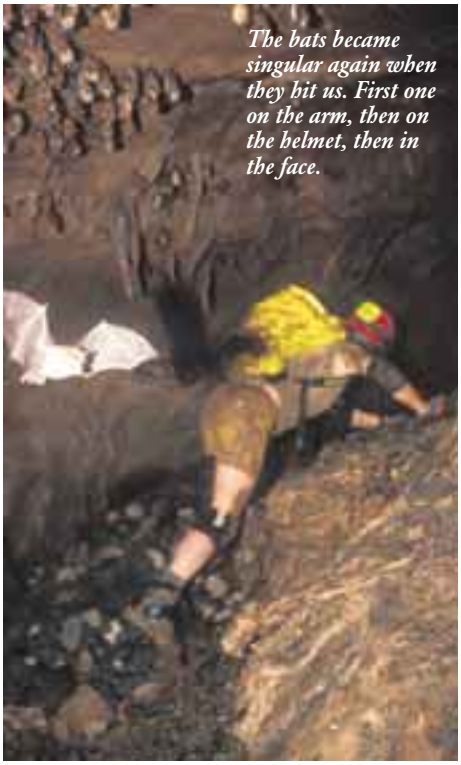
What started as a faint vision nearly five years ago became a reality for our team of three cavers from Canmore, Alberta last January. The karst landscape of Northwestern Thailand holds vast treasures of uncharted cave passages, many of which, however, are guarded by high concentrations of carbon dioxide. It was the nemesis of my previous expedition back in '98 to explore new cave passages: our team invariably got turned around by carbon dioxide. After a lot of research into bad air in caves, we set out to Thailand better equipped this time, carrying lightweight oxygen bottles and a Vaisala CARBOCAP® Hand-Held Carbon Dioxide Meter GM70.

Carbon dioxide (CO_2) is a deadly gas in high concentrations, which displaces oxygen and results in rapid asphyxiation. When entering uncharted passages, high carbon dioxide concentrations are one of the risks that cavers face, since an elevated CO_2 level can also impair one's judgment. However, reliable methods to measure CO_2 on cave expeditions have been scarce. An everyday butane lighter is often used: incomplete or nonexistent combustion will indicate that the oxygen levels are becoming dangerously low (around 15% or less). "When the lighter goes out, get out," was my simple but life saving motto during our '98 expedition. After our team had already pushed through a cave system, finding it to be the deepest in Thailand, fruitless sparks from the lighter were the last thing I wanted to see, going into a cave passage at a depth of over 1,000 feet. But it made us turn back, happy to reach the surface alive.

If you get into bad air, you turn around

Upon returning home from our '98 expedition, all I could think about was what was around that next corner in the depths of Thailand. Within 24 hours of getting off the plane, I was at the library researching carbon dioxide in caves on the internet. I found laborious research into the naked flame test in carbon dioxide caves and unsuccessful trails with heavy and cumbersome scuba tanks, but no serious attempts to penetrate deep with some sort of workable caving breathing apparatus. All the experts on high concentrations of CO_2 in caves gave me the same answer: "If you get into bad air, you turn around." I looked into self contained breathing apparatus (SCBA) and equipment from the fire fighting industry ➤

"When the lighter goes out, get out," is the caver's traditional life saving motto when entering uncharted cave passages.



The bats became singular again when they hit us. First one on the arm, then on the helmet, then in the face.

which were far too cumbersome for caving where you have to negotiate passages that you can barely fit your own flexible body around, let alone a rigid backpack. Their supply of an hour or two would not be enough for a full day or more underground. SCBAs from the aviation industry were a bit closer, but still not workable. When chatting with a friend about how the carbon dioxide displaces oxygen, I made an analogy to the "thin air" found in high altitude mountaineering and realized that supplemental oxygen is the answer. Small, lightweight tanks used in mountaineering pursuits would provide an 8–10 hour supply of pure oxygen and be readily refilled at any hospital in Thailand. After discovering this, I submitted proposals for various grants to find sponsors and funding for a new try.

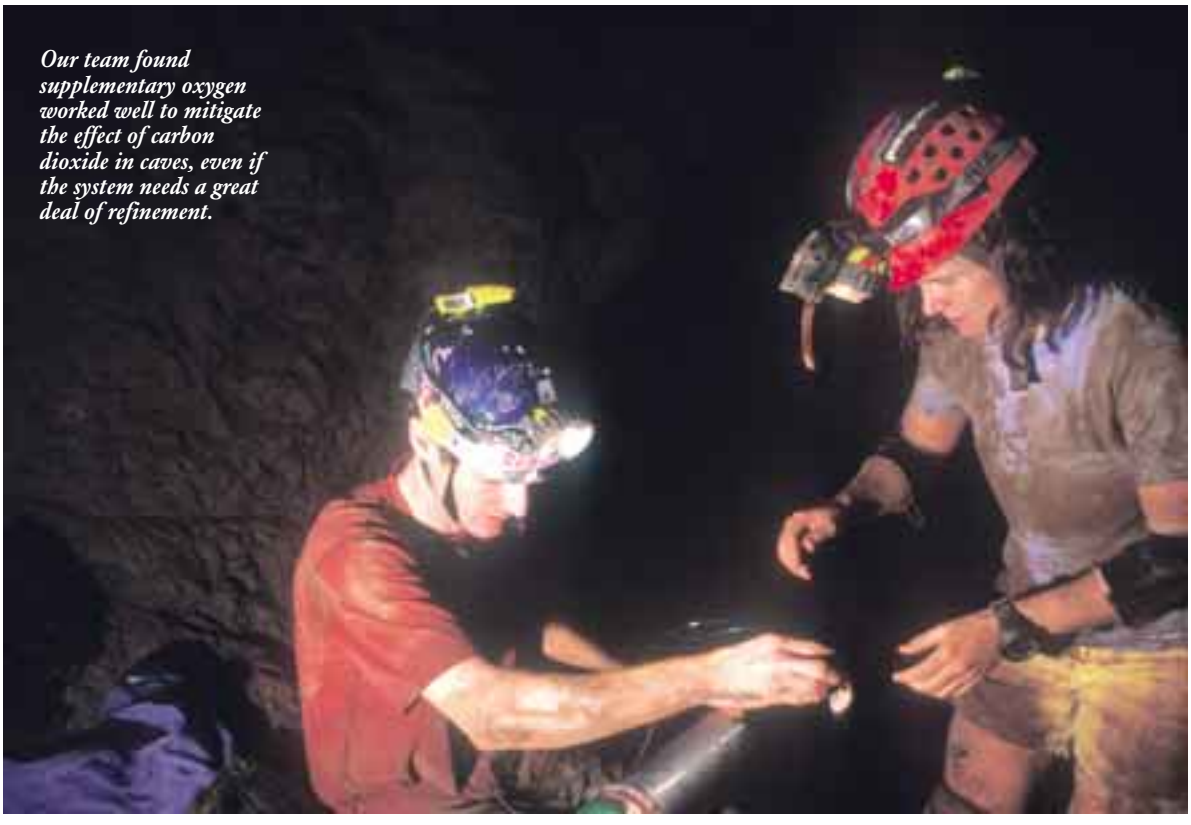
Forgotten dream revived

Three years later, my project nearly forgotten, I got a phone call informing me that our 'Tham Pha Puek Caving Expedition' had been awarded the Shipton/Tillman Grant of W.L. Gore and Associates. I asked for an extension from May to January, i.e. to the next dry season in Thailand, which is critical for caving. With the good news, the forgotten dream was revived and planning began. My tests of supplemental oxygen theory in "bad air" caves in Texas with up to 7% carbon dioxide showed that it worked. Next I put together the team of three – the most important decision of all. The perfect team members (Will Gadd and Maria Cashin) came from home in the small town of Canmore, Alberta, where a large community of climbers, mountaineers, and adventurers is active. National Geographic Adventure (NGA) and National Geographic Television (NGTV) staff who were covering the project also joined our team. Moreover, I was shooting still photography for NGA.

For product sponsorship, Chinook Medical Gear came through with the high-altitude supplemental oxygen tanks, regulators, and valves; Petzl delivered the caving equipment. As for a precision carbon dioxide meter, on which our lives would literally depend, I knew Vaisala had the best carbon dioxide meter around and contacted Vaisala Inc. One phone call to Dick Grönholm at Vaisala resolved the issue. "Your meter will be on its way tomorrow – just return it and let us know how things went when you get back," was his easy response.

Revisiting the cave

A couple months later, I sat at the bottom of the world in Thailand, in the same place where I had had to turn around back in '98. At the corner that had become an obsession, we were all poised at the edge of the unknown. Our team hadn't hit high levels of CO_2 the whole way down, and everybody seemed to be breathing just fine. It seemed too easy. Strangely disappointed not to have the long-time adversary waiting there for me, I suggested taking a CO_2 reading before going further. Will thought that the air was fine, but I insisted on taking out the meter for a reading anyway. "It's settling in… looks to be point five percent," he



Our team found supplementary oxygen worked well to mitigate the effect of carbon dioxide in caves, even if the system needs a great deal of refinement.

said. As a connoisseur of lighter flames, I also pulled out my lighter which fired right up with a perfect flame. Both tools told us that we could safely go for it, and we started the long belly crawl.

An unforeseen obstacle

Around that corner lay a tight squeeze, then the cave opened up into a big, easy cave passage again. We went at least another 600 meters before hitting an unforeseen obstacle: bats, thousands of bats. You couldn't think of them as individual bats anymore, but as a cloud constantly moving and swirling at the roof of the cave. Unfortunately, to continue down the cave we had to go up and over a hump and into the terrifying cloud. The bats became singular again when they hit us, and would fall to the ground stunned, flopping around miserably. We all freaked out and made funny, primal sounds at the bats whose sonar seemed out of order, and then ran back to the safety of the lower river passage of the cave. We regrouped and decided not to let the bats force us to return. In single file, using our cave packs as shields, we pushed through the "bat zone" to the safety of the lower cave passage on the far side. There our progress stopped as the flowstone touched the floor of the cave.

Since there was a flow of fresh air and bats usually hang out near the outside world, we desperately tried to find an exit, but to no avail. We found lots of spiders, insects, and even a surface dwelling frog during the precious hours we spent digging, probing and climbing in search of an exit. It was about not having to go back through the "bat zone" rather than about cave discovery. We finally gave up and, luckily, on the way out the bats didn't bother us so much. Either their sonar had improved, or our squeamish instincts had diminished, or probably a bit of both.

Studying carbon dioxide in caves

The remaining two weeks of our expedition were filled with looking for CO_2 in caves in order to test our theories and equipment and come back with useful information which was one of the main reasons we got the grant in the first place. It seemed ironic to go looking for the very thing most people try to avoid, but we found concentrations of up to 5% in several caves - plenty to test our supplemental oxygen systems. We made several observations about bad air caves, which are too detailed to summarize here. But overall we came to two general conclusions: firstly, the supplemental oxygen works well to mitigate the effect of carbon dioxide in caves. Secondly, our oxygen delivery systems would need a great deal more refinement before we would even consider putting ourselves in situations where our lives would depend on them.

The Vaisala carbon dioxide meter became our most trusted tool to access the cave environment in our studies. It got dragged over rocky cave floors, through unthinkable mud, hauled in cave packs up sheer rock walls, and floated inside dry bags in underground rivers. Towards the end of our expedition, it got dragged over rocky river bottoms that tore the dry bag. It finally succumbed to our abuse when immersed in a dry bag full of water. The GM70, which was so many things for us, met its specs by not being waterproof.

Many thanks to Dick Grönholm and everyone at Vaisala for helping to make our Thailand caving expedition a reality. Look for the National Geographic Adventure article in their October issue and the National Geographic Television coverage. ●

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